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PROGRESS REPORT
Heavy Solar Wind Ion Dynamics at and Downstream from the Bow Shock
Contract NASW-5037
(for the period ending 30 November 1997)

This progress report describes activities under NASA contract NASW-5037 to Lockheed-Martin Missiles and Space Company. The report covers the period from 31 July 1997 to 30 November 1997. This is a contract under the NASA Supporting Research and Technology Program for the analysis and interpretation of the scientific data from the Plasma Composition Experiment on the International Sun Earth Explorer 1 (ISEE-1) spacecraft and the Fast Plasma Experiment on the ISEE-1 and -2 spacecraft. These combined data sets will be used in a comprehensive study of the heavy solar wind ion dynamics at and downstream from the Earth's bow shock. The report summarizes activities during the above period and outlines expected activities during the forthcoming quarter.

DATA ANALYSIS ACTIVITIES

With the completion of the work in the last reporting period, we have turned our attention to the ultimate fate of He^{2+} and other minor ions. Most of the plasma that crosses the bow shock convects past the magnetopause and returns to the solar wind. However, a small but important fraction of this plasma enters the Earth's magnetosphere. We are currently studying two different entry points, the polar cusps and the flanks of the magnetopause.

The results of the study in the previous reporting period were already put to use in the polar cusp using data from the POLAR spacecraft. It was observed that the $\text{He}^{2+}/\text{He}^+$ density ratio in the cusp was higher than that in the solar wind near the equatorial edge of the cusp. This difference in the density ratio was shown to be a direct result of the difference in the heating across the bow shock from the above study. We are currently investigating the differences between the quasi-parallel and quasi-perpendicular shock and its affect on the cusp precipitation. One difference should certainly be an increase in the energetic ion fluxes in the cusp. However, there is more to this effect than a simple flux increase. Because the $\text{He}^{2+}/\text{H}^+$ phase space density is higher for energies above 10 keV/e than for energies below 1 keV/e downstream from the shock, one should also see a similar effect in the cusp. Recent analysis of the polar data suggest that this is

indeed the case. Additional affects on the He^{2+} and H^+ distributions may also be seen in the cusp. This work is ongoing.

A second ongoing study uses the results of the injection to investigate how the solar wind He^{2+} crosses the magnetopause at the flanks and ultimately becomes part of the plasma sheet. In this study, we have found that the boundary layers near the plasma sheet are complicated. However, the He^{2+} density ratio in these layers are somewhat simple to interpret. In particular, there are layers we identify with the mantle which have a very low density and other layers which appear to be mantle-like but have higher density. These other layers we call the dense mantle. Furthermore, there are classical plasma sheet intervals and other intervals that appear to be a mix of the plasma sheet population and a second population that looks like the cold, dense mantle. These regions we call “mixed regions” for lack of a better term.

The various regions are not new. However, the composition results we have found are new.

Figure 1 shows the O^+/H^+ density ratio as a function of the H^+ density in the Dense Mantle (solid squares) and the Mantle (open squares). As expected, the H^+ density of the Dense Mantle is, on average, larger than that in the Mantle. The average density in the Dense Mantle is $\sim 1 \text{ cm}^{-3}$ whereas the average density in the Mantle it is $\sim 0.1 \text{ cm}^{-3}$.

For a constant O^+ density, an increase of a factor of 10 in the H^+ density would result in a decrease in the O^+ density ratio by an equal amount and all data would lie on the line at 45 degrees in the plot. Because the data follow this line, we can conclude that there is no change in the O^+ density from the mantle to the Dense Mantle. The additional plasma appears to be entirely H^+ .

Figure 2. shows that the He^{2+} density and the H^+ density are correlated in the Mantle and the Dense Mantle. An almost constant $\sim 4\%$ He^{2+} concentration is observed in both regions. Combining the results of Figures 1 and 2, the additional plasma in the Dense Mantle appears to be entirely of solar wind origin.

Figure 3 shows the O^+/H^+ density ratio as a function of the H^+ density in the Mixed Region (solid squares) and the Plasma Sheet (open squares). Although not as clear as in Figure 1, the Mixed Region appears to have a higher H^+ density on average than that in the Plasma Sheet. The average Mixed Region density is $\sim 1 \text{ cm}^{-3}$ whereas the average density in the Plasma Sheet is $\sim 0.2 \text{ cm}^{-3}$.

As with the Dense Mantle/Mantle comparison, the O^+ density in the Mixed Region and in the Plasma Sheet appears to be constant. The almost factor of 10 increase in the H^+ density from the Plasma Sheet to the Mixed Region is accompanied by an equal decrease in the O^+/H^+ density ratio.

Figure 4 shows the He^{2+} density and the H^+ density are correlated in the Plasma Sheet and in the Mixed Region. There is an almost constant ~2-3% He^{2+} concentration in both regions. Because of the effects of the upper energy cutoff of the instrument discussed above, we can conclude that this density ratio is biased low. Independent of the actual concentration, it is clear that the relative concentration does not change from one region to another. Thus, as with the Dense Mantle and Mantle comparison, it appears that the additional plasma in the Mixed Region is entirely of solar wind origin.

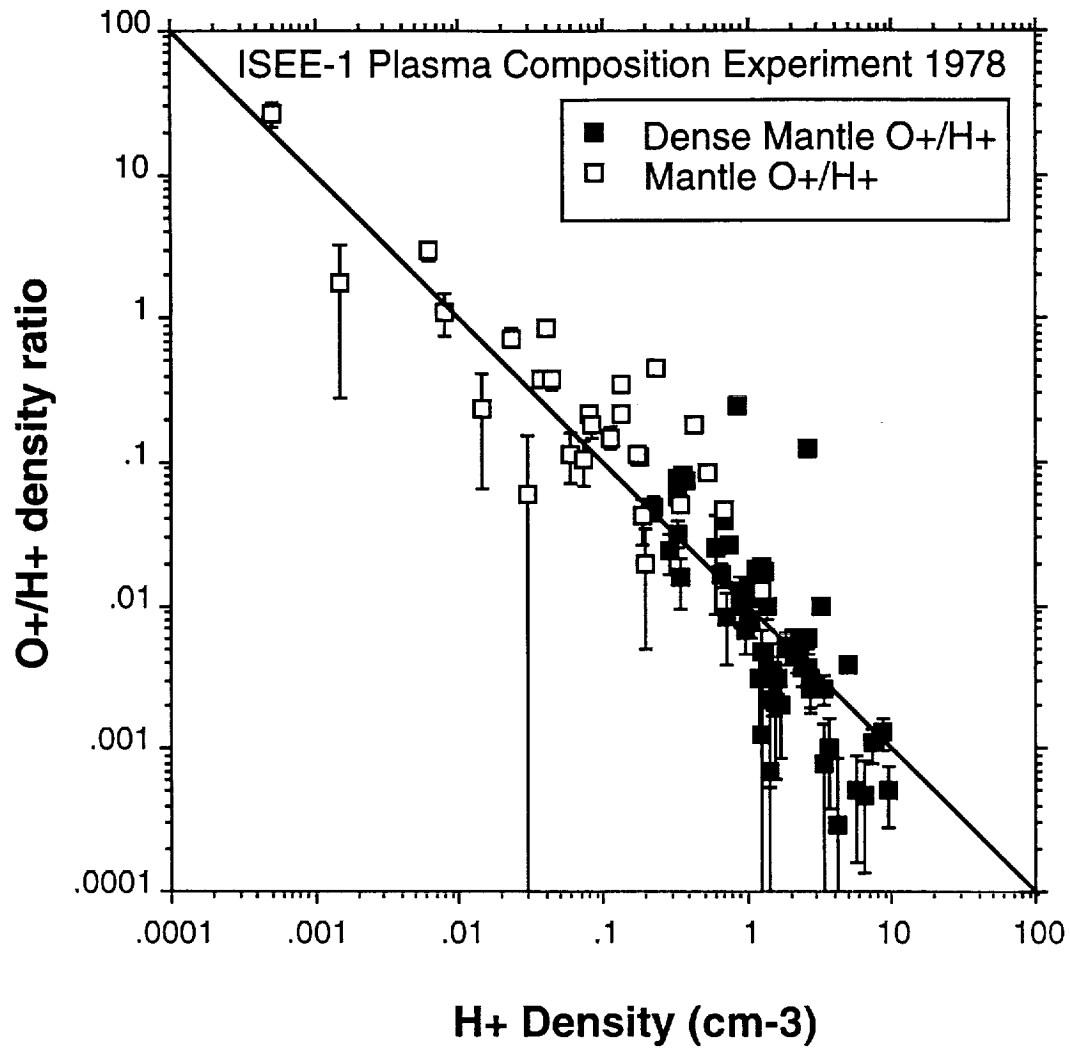


Figure 1. Comparison of Dense Mantle and Mantle O+/H+ density ratios. Additional plasma in the dense mantle appears to be entirely H+ with no additional O+.

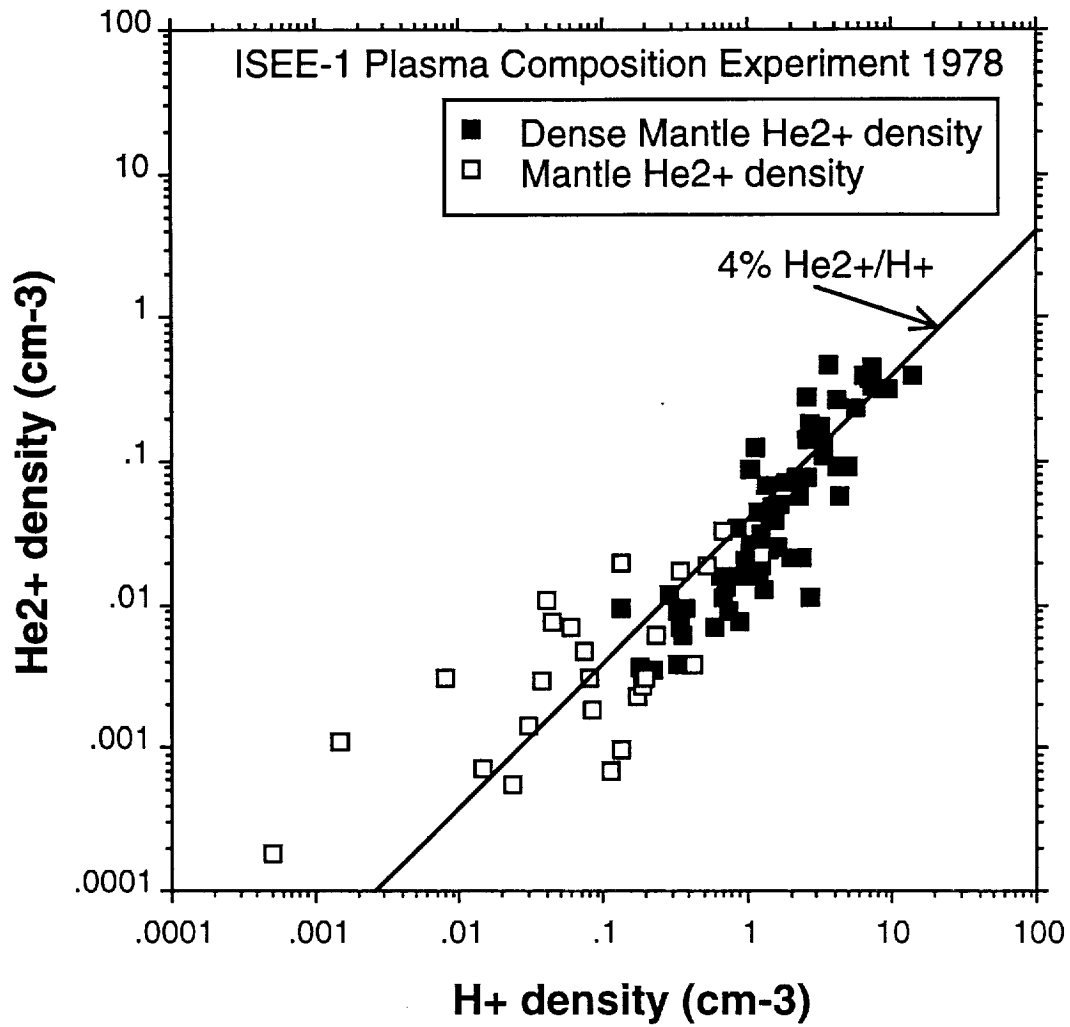


Figure 2. Comparison of Dense Mantle and Mantle He2+ and H+ densities. Additional plasma in the dense mantle appears to be entirely of solar wind origin with no additional magnetospheric H+.

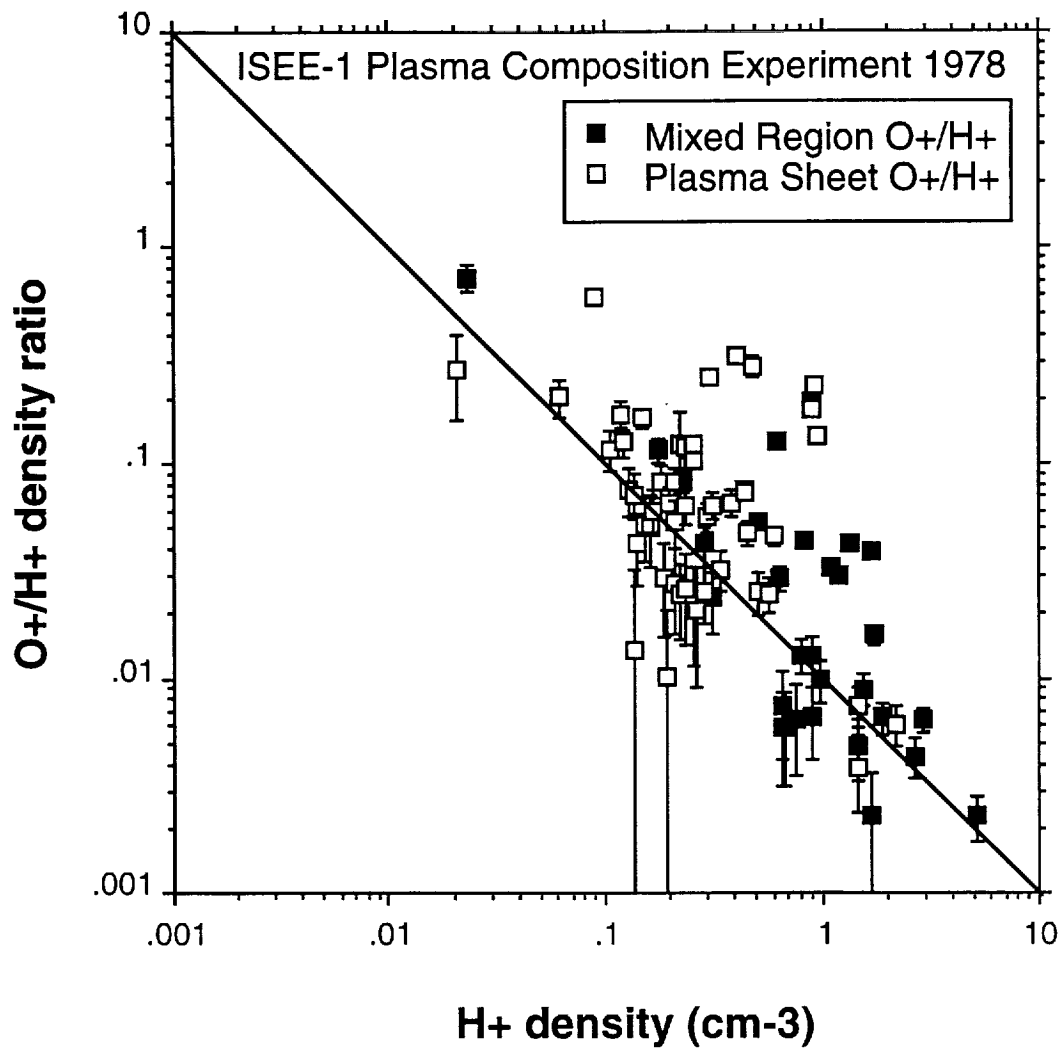


Figure 3. Comparison of Mixed Region and Plasma Sheet O^+/H^+ density ratios. Additional plasma in the Mixed Region appears to be entirely H^+ with no additional ionospheric O^+ .

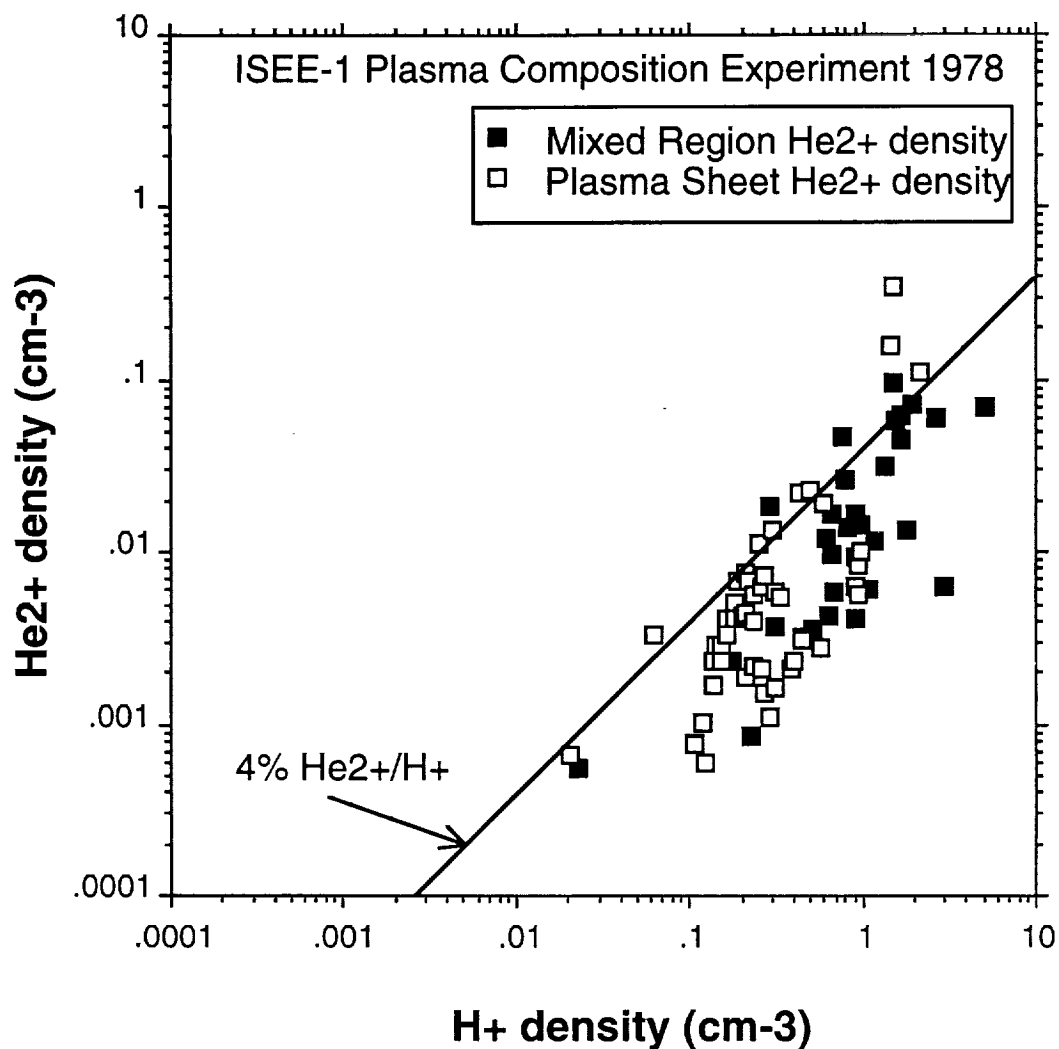


Figure 4. Comparison of Mixed Region and Plasma Sheet He2+ and H+ densities. Additional plasma in the Mixed Region appears to be entirely of solar wind origin with no additional magnetospheric H+.

PUBLICATIONS

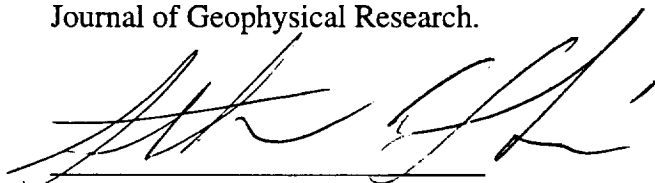
No papers were submitted or published during this reporting period.

PRESENTATIONS

No papers were submitted for presentation at conferences or other scientific forums.

ANTICIPATED ACTIVITIES DURING THE FORTHCOMING QUARTER

During the next quarter, the study on the ultimate fate of the ring-beam distribution will be finished and preparation of a manuscript will begin. These results will be presented at an appropriate scientific conference in the near future and the paper will ultimately be submitted to the Journal of Geophysical Research.

A handwritten signature in black ink, appearing to read 'SAF', is written over a horizontal line.

Stephen A. Fuselier